

CLAIMS

WE CLAIM AS OUR INVENTION:

1. A method of controlling fuel flow to prevent an overload of an internal
5 combustion engine as the engine ages, the method comprising:

limiting fuel flow delivered to the engine to a maximum allowed value in
order to prevent an undesirable operating condition for the engine; and

adjusting the fuel flow maximum allowed value in response to a trend in
performance of the engine over time.

10

2. The method of claim 1, further comprising varying the maximum
allowed value in response to a fuel usage parameter.

3. The method of claim 2, further comprising varying the maximum
15 allowed value in response to fuel usage per unit of performance of the engine.

4. The method of claim 3, further comprising determining a fuel usage
per unit of performance parameter as one of rate of fuel flow per horsepower
produced by the engine, rate of fuel flow per engine stroke, rate of fuel flow per unit
20 of speed of a vehicle propelled by the engine; and rate of fuel flow per unit of torque
produced by the engine.

5. The method of claim 4, further comprising normalizing fuel usage as a
function of an environmental condition.

25

6. The method of claim 1, further comprising applying a low pass filter to
a parameter indicative of performance of the engine over time to enable variation of
the maximum allowed value in response to engine wear and to prevent variation of the
maximum allowed value in response to engine component failure.

30

7. The method of claim 1, further comprising applying an averaging function to a parameter indicative of performance of the engine over time to enable adjustment of the maximum allowed value in response to engine wear and to prevent adjustment of the maximum allowed value in response to engine component failure.

5

8. The method of claim 7, further comprising providing an alarm responsive to a difference between an input to the averaging function and an output of the averaging function.

10

9. The method of claim 1, further comprising varying the maximum allowed value in response to an output of a learning function responsive to performance of the engine.

15

10. The method of claim 9, further comprising applying a variable time constant to the learning function.

11. The method of claim 9, further comprising applying the output of the learning function to a fuel control function.

20

12. The method of claim 9, further comprising applying the output of the learning function to an engine load control function.

25

13. In a fuel control system for an internal combustion engine of a locomotive wherein fuel flow is controlled to be responsive to a demand signal and wherein fuel flow is limited to be no more than a maximum allowed fuel flow value in order to prevent the occurrence of an undesirable operating condition, a method comprising varying the maximum allowed fuel flow value over time in response to a measured parameter.

30

14. The method of claim 13, further comprising varying the maximum allowable fuel flow value in response to an engine performance parameter.

15. The method of claim 14, further comprising varying the maximum allowable fuel flow value in response to fuel usage per unit of engine performance.

5 16. The method of claim 14, further comprising varying the maximum allowable fuel flow value in response to fuel usage compensated for an environmental condition per unit of engine performance.

10 17. The method of claim 15, further comprising varying the maximum allowable fuel flow value in response to one of rate of fuel flow per horsepower produced by the engine, rate of fuel flow per engine stroke, rate of fuel flow per unit of speed of the engine; and rate of fuel flow per unit of torque produced by the engine.

15 18. The method of claim 13, further comprising varying the maximum allowable fuel flow value in response to a change in an engine performance parameter that passes a low pass filter.

19. The method of claim 18, further comprising alarming a change in the engine performance parameter that is filtered by the low pass filter.

20 20. A method of controlling fuel flow to an internal combustion engine, the method comprising:

establishing a maximum allowed fuel flow value for the engine;
measuring an engine performance parameter;
applying a learning function to the engine performance parameter; and
25 using an output of the learning function to determine a variation in the maximum allowed fuel flow value.

21. The method of claim 20, further comprising applying a variable time constant to the learning function.

22. The method of claim 20, further comprising applying an averaging function to the engine performance variable to enable changes to the maximum allowed fuel flow value in response to engine wear and to prevent changes to the maximum allowed fuel flow value in response to an engine component failure.

5

23. The method of claim 22, further comprising detecting an engine performance variable change that is blocked by a low pass filter.

24. A method of controlling an engine, the method comprising:
10 limiting fuel flow delivered to the engine to a maximum allowed value in order to avoid an undesirable operating condition for the engine; and
varying the maximum allowed value in response to a variation in an ambient environmental condition affecting performance of the engine.

15 25. The method of claim 24, further comprising applying a learning function to the maximum allowed value.

26. An apparatus for controlling an internal combustion engine, the
apparatus comprising:
20 a regulator responsive to a demand signal and to a feedback signal to produce a fuel demand;
a fuel limiter responsive to historical engine performance data to produce an adaptive fuel limit; and
a controller responsive to the adaptive fuel limit and the fuel demand to
25 control fuel flow.

27. The apparatus of claim 26, wherein the fuel limiter further comprises:
a calculator responsive to the fuel demand signal and an engine power signal
to produce a fuel consumption per unit power signal;
a low pass filter responsive to the fuel consumption per unit power signal to
5 produce a filtered fuel consumption per unit power signal; and
a multiplier responsive to the filtered fuel consumption per unit power signal
and to a maximum power rating signal to produce a fuel limit signal.

28. The apparatus of claim 27, further comprising:
10 a comparator responsive to the fuel consumption per unit power signal and the
filtered fuel consumption per unit power signal to produce a difference signal; and
an integrator responsive to the difference signal to produce a failure level
signal.

29. The apparatus of claim 28, further comprising a threshold detector
15 responsive to the failure level signal to produce a fault alarm.

30. A computer-readable medium containing instructions for causing a
computer system to control fuel flow to prevent an overload of an internal combustion
20 engine as the engine ages by:

limiting fuel flow delivered to the engine to a maximum allowed value in
order to prevent an undesirable operating condition for the engine; and
adjusting the fuel flow maximum allowed value in response to a trend in
performance of the engine over time.

31. The computer-readable medium of claim 30 further comprising
25 instructions for causing the computer system to vary the maximum allowed value in
response to a fuel usage parameter.

32. The computer-readable medium of claim 31 further comprising
30 instructions for causing the computer system to vary the maximum allowed value in
response to fuel usage per unit of performance of the engine.

33. The computer-readable medium of claim 32 further comprising instructions for causing the computer system to determine a fuel usage per unit of performance parameter as one of rate of fuel flow per horsepower produced by the engine, rate of fuel flow per engine stroke, rate of fuel flow per unit of speed of a vehicle propelled by the engine; and rate of fuel flow per unit of torque produced by the engine.

34. The computer-readable medium of claim 33 further comprising instructions for causing the computer system to normalize fuel usage as a function of an environmental condition.